

UK residential high-rise experience, fire safety and sprinkler protection

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Background / introduction

- Engineer by training:
 - MEng (Engineering and Engineering Management) [Mechanical and Electronic] Exeter University 2001
 - EngD (Fired firefighting system specification) Loughborough University 2015
- GSK 2001-2005 [innovative R&D systems]
- BRE / LPCB 2005-2009 [Head of Suppression]
- FPA 2009 – 2018 [A.D. and Director of FFS]
- FFSB 2018 onwards

About FFSB

- 
- Consultancy services
 - Standardisation participation
 - Design Review
 - Hazard Review
 - System Inspections
 - Expert Witness Services

What is “*high rise*” residential?



1 storey



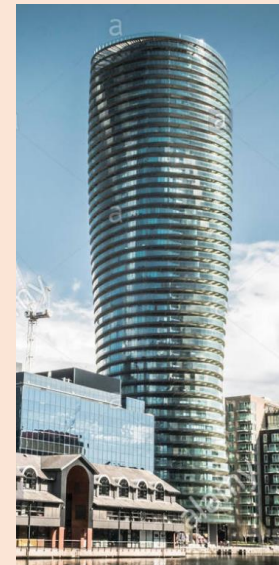
2 storey.....



4-8 or more storey



17 storey



Many, many storeys

What is “*high rise*” residential?

- A *high-rise building* is a tall building, as opposed to a *low-rise building* and is defined differently in terms of height depending on the jurisdiction (Wikipedia)
- UK Approved Document B talks about:
 - “*Buildings*” over 30m in height
 - “*Very tall buildings*”, typically over 45m in height
 - But no actual definition provided
- EN 12845 defines “*high rise*” as >45m
- EN 16925 excludes buildings taller than 18m or 4 stories.

What is “*high rise*” residential?

- Does requiring sprinklers mean a building is high rise?
 - UK: Wales = all domestic and residential buildings shall be sprinkler protected
 - UK: Scotland = all new care homes, “high rise” buildings (with a roof above 18m)
 - UK: England = 30m (now), reduction (soon) to 11m or 18m proposed.
- So, “no”.
- Conclusion: there is no single definition of “high rise” in UK
 - ~ Maybe you have a definition in Norway (?) ~
- My personal opinion: whilst design freedoms are attractive, more prescriptive guidance would be beneficial
- Meanwhile, the term “High rise” is not that helpful, instead consider **risk profile**.
- Certain requirements generally occur at certain building heights (an approximation of risk profile)

High rise fire safety design considerations

Higher rise buildings will inevitably pose additional fire safety challenges:

- Means of escape – much more difficult
- Greater potential for spread of fire and smoke
- More people at risk
- Greater potential consequences
- Firefighting access
- Density of occupation
- Vulnerable persons

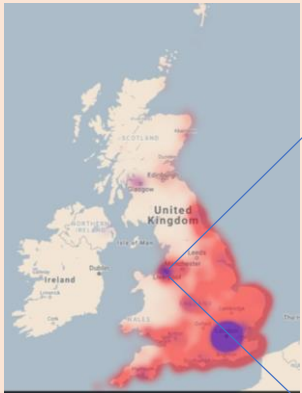
These issues can all be managed but it is quite complex to do so.



Fireman's safety net demonstration
1930s.

Brief history: first wave

- ‘Modern’ high rise residential construction began in UK in 1950s.
- Due to:
 - WW2 bomb damage (like much of Europe)
 - Slum clearance
 - Population housing needs



Brief history: first wave

- This first wave of high rise construction was initially popular:
 - Bathrooms, spacious rooms, heating and relative luxury
 - Nice views
 - 'Modern' and futuristic way of living
- However, quickly became unpopular:
 - Poor planning
 - Ugly concrete
 - Construction quality issues
 - High crime
 - Neglect and depravation
 - Complex political influences (socialism vs capitalism etc)
- High rise residential **not popular** 1980s onwards
- High rise residential development stopped



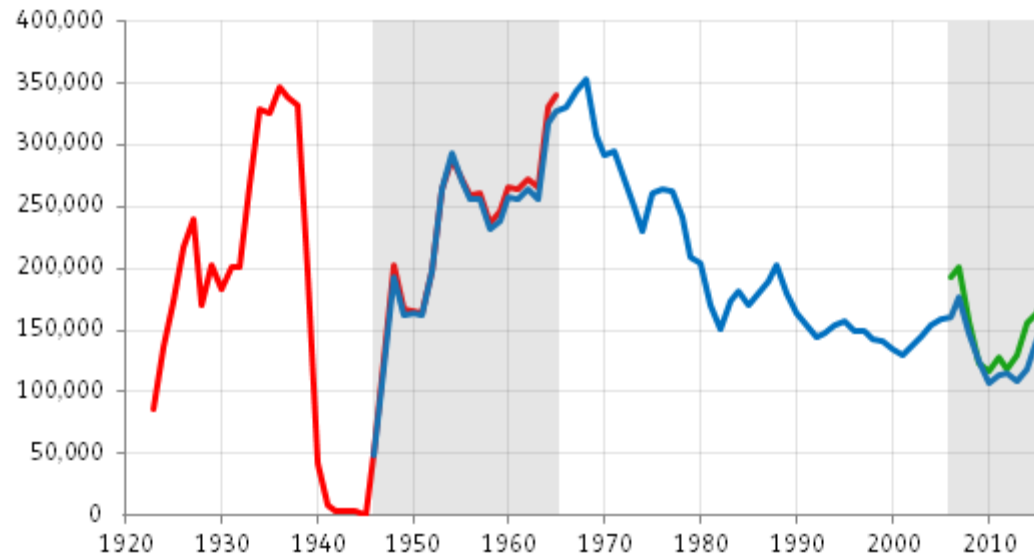
1960s style



Brief history

House building since the 1920s

Permanent dwellings completed in England*, 1923-2017**



Brief history: second wave

- Since ~2000s, a combination of:
 - Chronic housing shortage
 - Lack of land (available with planning consent)
 - Hyper-inflated house prices
- Has led to a second wave of high rise residential development in UK.
- The second wave enjoys much greater design freedoms than the first wave.



Vs.



High rise fire safety design considerations

Early UK high rise residential construction generally relied upon prescriptive measures of fire resisting construction (“passive” measures) to manage fire risk

1962, BSI published CP3 chapter IV part 1 recommendations for fire precautions in blocks of flats over 80ft (24m). It generally required:

- Concrete construction (with very high fire resistance ratings)
- Stay put policy
- No fire alarms
- Protected entrance halls within flats (e.g. fire wall between lounge and entrance-exit way to common building part)
- Bedrooms open directly onto entrance hall and be nearer the exit than the lounge or kitchen OR have a direct means of escape.
- Living room and kitchen doors solid and fire resisting
- Maisonettes; second means of escape onto different floor
- Maximum travel distances 30m
- Sprinklers only became required in blocks of flats >30m tall in 1992.

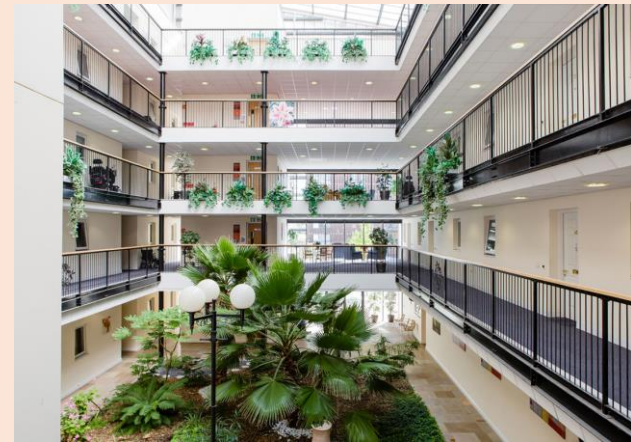
High rise fire safety design considerations

- At the same time as the second wave:
 - Very extensive de-regulation government agenda, and
 - weaker enforcement, and
 - growth of Fire Engineering, and
 - environmental initiatives, e.g:
 - Improved thermal performance of buildings
 - Reduced use of concrete (embedded CO2)
 - Increased use of timber (and other alternative more combustible materials)
 - Increased use of insulating materials (many of which are combustible)
- Have led to:
 - Less clear requirements
 - Much greater use of combustible material in construction
 - Continuing trend of improving fire statistics (?!)
 - Government (and society) was complacent - until Grenfell
- In UK, serious issues have manifested on both new-build and refurbished older housing stock as a result of the current regulatory framework.
- Dame Judith Hackett condemns 'race to the bottom' in building safety practices

Case studies – in brief...

Case studies: Retirement village

- Sheltered housing
- 121 flats
- 6 storeys (~15-18m)*
- ~100m x 30m footprint
- Built 2006
- Sprinklers in building but not car park below building



<https://www.ife.org.uk/Firefighter-Safety-Incidents/2006-monica-wills-house/41922>

Case studies: Retirement village

- Fire on 20/12/2006
- 22 cars in car park under building
- 1 fatality
- 77 occupants evacuated
- Sprinklers actuated and prevented further spread
- Car park should have been sprinkler protected

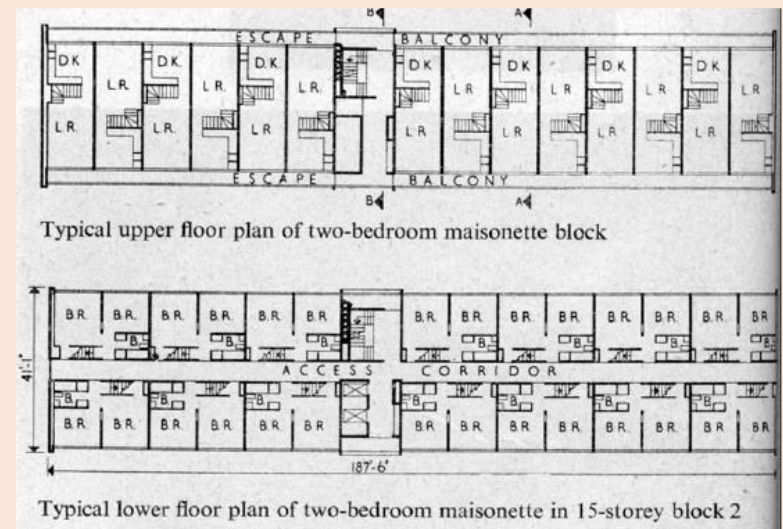
Chief Fire Officer Kevin Pearson "I am absolutely convinced that had it not been for the sprinkler system and fire safety measures in the building, alongside the prompt arrival of firefighters on the scene, we would have seen scores of lives lost at this incident"



<https://www.ife.org.uk/Firefighter-Safety-Incidents/2006-monica-wills-house/41922>

Case studies: Lakanal House

- Social housing (some private sector – ‘right to buy’)
- 98 flats
- 14 storeys (42m)*
- ??? residents
- Built 1960
- Therefore no sprinklers
- “stay put policy”
- Complex alternating layout (to comply with regs)



Case studies: Lakanal House

- Fire on 3/7/2009
- 9th floor (start)
- Single staircase design – filled with smoke
- Fire spread up, down and along escape corridors
- 6 fatalities + more injuries



Case studies: Lakanal House

- Fire starts (1)
- Spreads up to 11th floor (2)
- Spreads along 11th floor (3)
- Falling debris spreads downwards to 7th floor (4)
- Falling debris spreads downwards to 5th floor (5)
- Also some flash-over in corridors



Case studies: Lakanal House

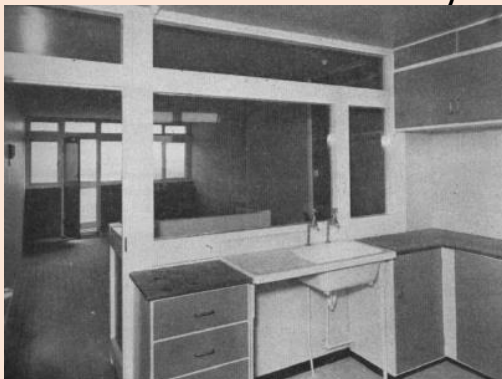
- Originally fire-sterile building
- Refurbishments introduced combustible materials
 - Cladding
 - Multiple paint layers (13) in corridors
 - Cables
 - False ceilings and ducts
- Passive fire resting construction had been compromised (e.g. bathroom ducts)



Multiple layers of paint



Addition of false ceiling

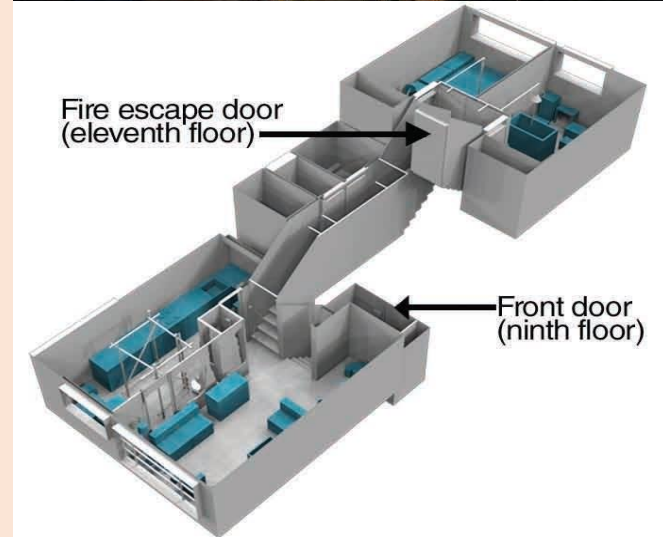


Case studies: Lakanal House

- Coroner made several strong recommendations:
 - Criticism of the 'stay put' policy and residents not being clear on what to do
 - Quality and scope of Fire Risk Assessments to be improved
 - Sprinkler retro-fit
 - Criticism of Approve Document B for it's complexity and lack of clarity
 - Improvements to high rise firefighting practices
 - Provision of better information about the building for F&RS in an emergency
- The government response was considered weak. Generally only bringing the issues "*to the attention of*" interested stakeholders.

Case studies: Shirley Towers

- Social housing (some private sector – ‘right to buy’)
- 150 flats
- 15 storeys (46m)*
- 400 residents
- Built 1967
- Therefore no sprinklers
- “stay put policy”
- Complex ‘scissor’ layout (to comply with regs)

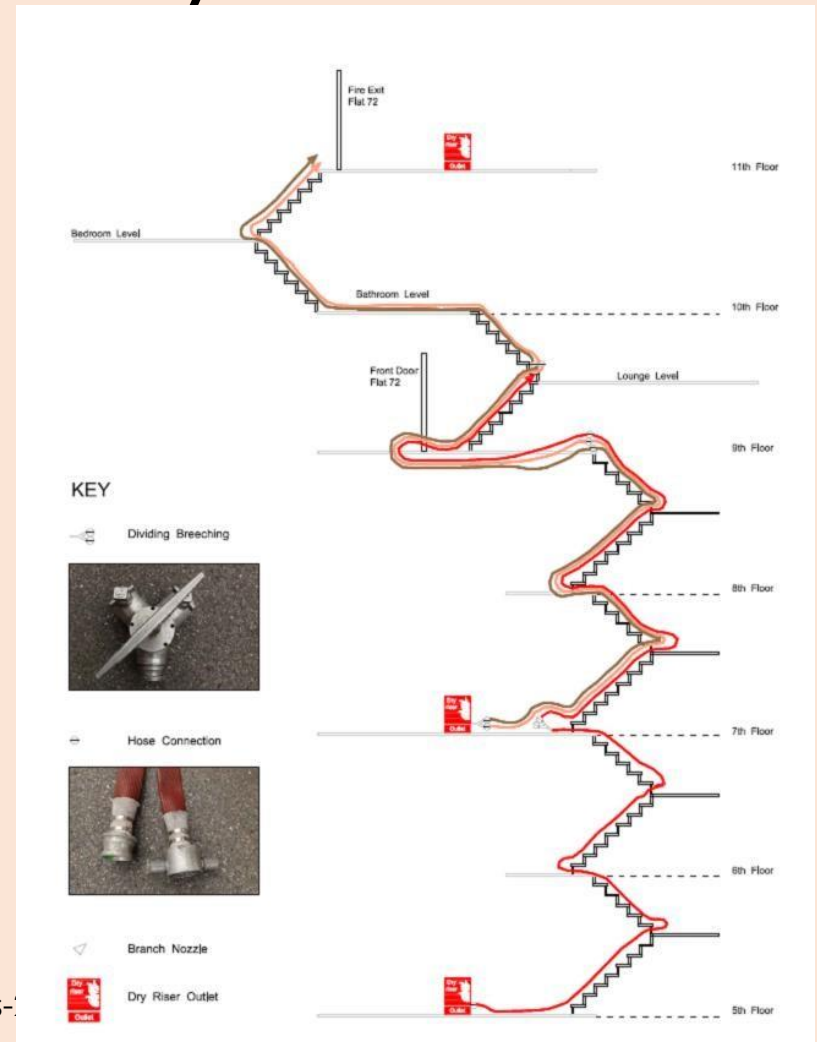


<https://www.ife.org.uk/Firefighter-Safety-Incidents/shirley-towers-2010/34619>

Case studies: Shirley Towers

- Fire on 6/4/2010
- 9th floor
- A seat of fire was missed
- Firefighters ended up above the fire
- Breathing Apparatus (BA) became trapped in cables
- Complexity of FF operations
- 2 fatalities (fire fighters)

<https://www.ife.org.uk/Firefighter-Safety-Incidents/shirley-towers->



Case studies: Shirley Towers

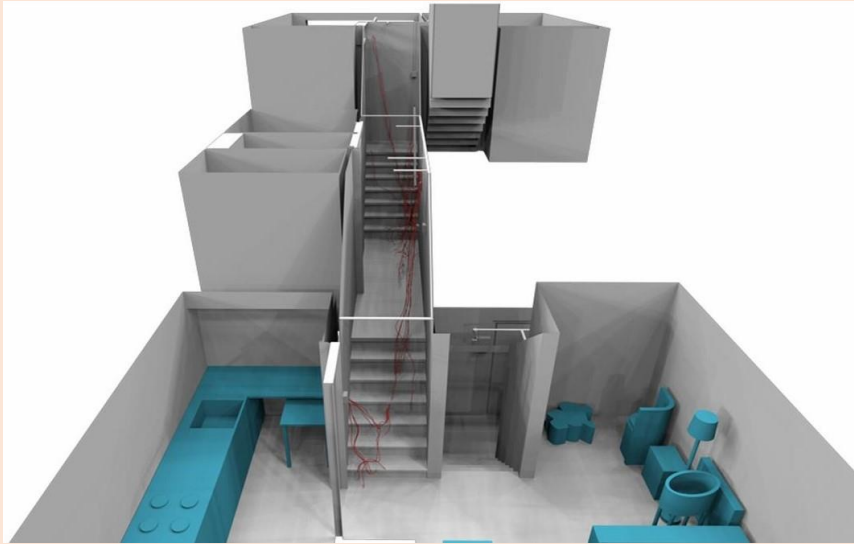
- Views within flat
- Complexity of hose routing/manoeuvring



<https://www.ife.org.uk/Firefighter-Safety-Incidents/shirley-towers-2010/34619>

Case studies: Shirley Towers

- Fallen cables in hall ways
- Fallen cables in flats



<https://www.ife.org.uk/Firefighter-Safety-Incidents/shirley-towers-2010/34619>

Case studies: Shirley Towers

- Coroner made several strong recommendations:
 - Improved BA control and fire fighting methods
 - Updates to teaching and training methods
 - Risks of fallen cables
 - Provision of wire cutters
 - Modifications to BA
 - Training
 - Do not use plastic (or non-fire resistant) cable supports
 - Consider retrofitting sprinklers to all existing high rise residential buildings over 30m in height
 - Improvements to signage
- The government response was considered weak. Generally only bringing the issues “*to the attention of*” interested stakeholders.

<https://www.ife.org.uk/Firefighter-Safety-Incidents/shirley-towers-2010/34619>

Case studies: Grenfell Tower [note: enquiry ongoing]

- Social housing (some private sector – ‘right to buy’)
- 129 flats
- 24 storeys (67m)*
- 600 residents
- Built 1974
- Therefore no sprinklers
- “stay put policy”



Case studies: Grenfell Tower [note: enquiry ongoing]

- Catastrophic fire on 14/6/2017
- 72 fatalities
- >70 more injured
- 223 escaped
- Spread from 4th to all residential floors
- Single staircase design – filled with smoke
- Combustible cladding system had been applied to exterior of the building in recent refurbishment
- Official enquiries ongoing



Case studies: Grenfell Tower [note: enquiry ongoing]

- Already resulted in radical review of regulations:
- Sprinklers look set to be required in England for all residential buildings of 11m in height or greater (was 30m)
- (Wales already requires sprinklers for all new residential buildings)
- Scotland was 18m and this may fall further
- Rules for fire resisting construction requirements look set to be clarified and improved



- F&RS training and response policy under review
- Many people are taking fire much more seriously...
- ...and many are not – I still see appalling conduct and decisions on a weekly basis

Case studies: West Hampstead Square

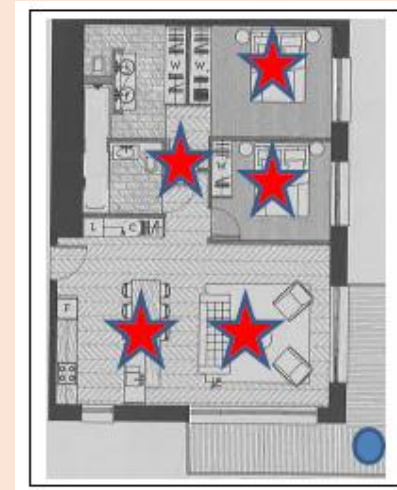
- Private housing
- 34 flats (in this block)
- 7 storeys (21m)*
- ~70 residents
- Built 2016



Case studies: West Hampstead Square

Fire safety measures:

- BS 9251 sprinklers (at request of LFB)
- Firefighting shaft/pressurised staircase.
- Smoke ventilation.
- Dry riser
- Automatic fire detection in non-residential areas
- Stay put policy/defend in place.
- 24/7 on site concierge/security



2 bed flat – layout and sprinklers



Studio flat – layout and sprinklers

Case studies: West Hampstead Square

- Fire on 3/7/2018
- 0 fatalities or injuries
- *Video clip...*

Case studies: West



Video: Maria Paz Garcia

Case studies: West Hampstead Square

- Fire started on a balcony (cigarette)
- Excessive fire spread via balconies
- Sprinkler system was designed to feed 2-4 heads – but as it took water from the domestic water supply it had significantly greater capability than BS 9251 required
- **12 sprinkler heads operated** (protecting the rest of the building)
- BRE (and others) have published their concerns over balcony construction techniques and materials.



LFB conclude: *Without the installation of AFSS, the outcome could have been much more serious and potentially fatal resulting in 5 separate uncontrolled compartment fires located over five floors, thereby significantly increasing the risk to residents and firefighters*

Sprinklers in high rise; common issues

- Which standard to use:
 - BS 9251 (in UK) ≈ BS EN 16925 (but only <18m/4 storeys)
 - BS EN 12845
 - BS 9251 currently being revised to enhance “high rise” design criteria
- Options: BS 9251 and BS EN 16925 suggest (not prescribe) “system enhancements” where there is additional risk. E.g:
 - Increased densities
 - Increased areas of operation
 - Dual (independent) power supplies for pumps
 - Duplicate pumps
 - What do you use and when..... ??? (client/consultant to decide)
- In UK, R&D sector is less mature than commercial and industrial sector (watch out for competency)
- Extent of protection (e.g. bathrooms, car parks, etc)
- Hydraulics – very high rise (>45m) PRVs or ‘stages’ ?
- Mixed use – BS 9251 not very clear on what to do
- EN 12845:2015 – not very clear on what to do with R&D (e.g. when beyond scope of EN 16925) (heads, spacings, densities etc).

Sprinklers; common issues

- CPVC (and other plastic) pipework
- Can be a very helpful product (especially retro-fit)
- Watch out for:
 - Designer and installer competency
 - Chemical sensitivity; ESC (Environmental Stress Cracking)
 - At install
 - Through-life
 - Increased densities required in some (many) circumstances (e.g. 2.8mm/min → 4.1 mm/min if used “exposed”)
 - Installer competency
 - Requirements of user manuals
 - Riser heights (>18m)

Water mist

- Can be very effective, especially in local application scenarios
- Mist has many apparent attractions (modern, efficient, smaller pipe sizes, smaller tanks sizes (?)) Less water damage (x), etc)
- In UK we have BS 8458 (domestic and residential) and BS 8489 (commercial, industrial and some higher risk residential)
- In Europe, prEN 14972-1 will probably soon be published.
- However:
 - More complicated in many respects (physics, nozzle orifice sizes, application specific)
 - Immature standards (in my opinion)
 - DIOM concept; problematic if over relied upon
 - Generally proprietary e.g.:
 - not interchangeable
 - less resilient supply chain
 - less competition / cost issues
 - maintenance considerations
 - Few or no fully (component, system, installer) third party approved solutions for many applications
 - Little/no applicable reliability data – what are you buying ???
 - Many, many problems experienced in UK.
- FFSB advise much greater caution.

Sprinklers; generally very reliable

Table 4 – Sprinkler reliability based on UK experience

Occupancy	% where equipment operated	% performance effectiveness	% operational reliability
Dwelling	97.7	99.5	97.2
Non-residential	93.8	99.0	92.9
Other residential	97.7	100	97.7
Unknown building type	94.6	99.0	93.7
All	95.3	99	94.3

NOTE See Efficiency and effectiveness of sprinkler systems in the United Kingdom: an analysis from fire service data [19]

Table 5 – Sprinkler reliability by occupancy based on USA experience

Occupancy	% where equipment operated	% effective of those that operated	% where operated effectively
Offices	91	96	87
Restaurants	90	92	83
Storage	86	96	82
Residential	93	96	89
All	92	96	88

NOTE See U.S. Experience with sprinklers [20].

[19] Optimal economics (2016). Efficiency and Effectiveness of Sprinkler Systems in the United Kingdom: An Analysis from Fire Service Data.

[20] NATIONAL FIRE PROTECTION ASSOCIATION. U.S. Experience with Sprinklers. Ahrens, USA, 2017.

Coming soon in UK...

- Revised BS 5306-0
“Guide for selection, use and application of fixed firefighting systems and other types of fire equipment”
- [which system to use]
- Grenfell tower enquiry findings
- Many more changes to regulations and guidance

Further reading

Learn from UKs mistakes for free

- BRE, Fire safety issues with balconies

<https://www.bre.co.uk/filelibrary/Fire%20and%20Security/FI---Fire-safety-and-balconies-July-16.pdf>

- London Fire Brigade

<https://www.london-fire.gov.uk/media/3488/west-hampstead-square-afss-activation-case-study.pdf>

- IFE database

<https://www.ife.org.uk/Firefighter-Safety-Incidents>

- Dame Judith Hackett Independent Review of Building Regulations and Fire Safety: Final Report

<https://www.gov.uk/government/publications/independent-review-of-building-regulations-and-fire-safety-final-report>

Further reading

A more positive example:

- BAFSA Callow Mount sprinkler retrofit case study

https://www.bafsa.org.uk/wp-content/uploads/bsk-pdf-manager/2017/09/CALLOWMOUNT_web0407LR_lowres.pdf

Thank you – any questions ?

